**Space Syntax**  
**John Peponis, Ph.D.**

How can street and block design reconnect urban neighborhoods? How can workplace design make knowledge-work more productive? How can office layout express organizational culture and improve employee satisfaction? These are very diverse questions concerning design, the evaluation of design, and our understanding of the principles of form. However, they all require that we think of space as a pattern of relationships whose structure we want to understand and work with in some way. The morphology lab at the Georgia Institute of Technology, which I lead, has tackled these questions by extending a coherent family of ideas and analytical techniques: space syntax.

This issue of *Implications* explains the premises, principles, development, and application of space syntax and describes three projects that use space syntax to address the questions above.

Space syntax studies the principles we use when designing space. It can be introduced as an attempt to make explicit the spatial relationships that underlie our everyday experience of the designed environment and the way it functions culturally and socially. If I describe my home as a 1,600 square foot, 3-bedroom apartment I say nothing about the way in which my office is screened off such that it functions alternatively as an extension of the living room or as an independent space; I do not communicate the manner in which several people can gather around a kitchen worktop when cooking; nor do I say anything about how the elongation of the living room situates most conversations or diners between a series of windows along the front and a library at the back. At a more basic level, “home” also supposes other relationships that are so fundamental to one’s culture that they are taken for granted. One would hardly expect to enter the apartment and find the bedrooms more exposed than the living room or the dining room very far from the kitchen.

Space syntax is about identifying, representing, and measuring the spatial relationships that help us get on with our lives. The creation of these relationships is among the main purposes served by our built environment. And while we would not be able to live our everyday lives without a working understanding of the principles and constraints that govern these relationships, their deliberate creation or transformation through architectural design requires theory. The aim of space syntax is to arrive at an understanding of principles of spatial design and a critical evaluation of precedents and prospects.
This is the common ground of an expanding community of practitioners, researchers, and scholars.

**Describing, Explaining, Predicting, Designing**

How does space syntax help to deal with design questions, such as those about street design and neighborhood connections or about workplace design and productivity? Space syntax is an expanding set of analytical techniques and measures that are used to test a growing number of specialized hypotheses about the functions and effects of designs. The techniques all assume there is an intelligible structure to built space as it is perceived and explored by users moving through space. Therefore, the techniques add up to a common framework for describing how spatial environments enable or impede users’ behaviors. At the same time, each specialized research inquiry (e.g., about neighborhood connections or workplace productivity) is examined based on its own merits rather than as a part of an overarching theory.

For example, to deal with street connectivity and design we represent space as a network of potential lines of movement. We study the possible paths that link any two locations (topology); the number of direction changes along a path (directional structure); and the distance between intersections, length of uninterrupted street lines, and the widths of streets (metric properties) in street networks.

We use measures of closeness-centrality (integration) to identify the streets that minimize directional or metric distances from all possible destinations; we use measures of betweenness-centrality (choice) to identify the streets that are most likely to function as through-routes for all possible trips. From a mathematical point of view, most of the measures deal with how systems of nodes are linked by lines; that is, they are “graph-theoretic.”

Before we apply graph theoretic measures, however, we have to read the geometry of a space and translate it into a pattern that supports the type of analysis to be performed (e.g., intersecting lines of movement, connected 2-D convex spaces, intersecting visual polygons). Thus space syntax can be understood as a two-faced tool that can be used to read geometry and to interpret geometry in a graphic, analytical way. This task can be complicated, because our intuitive understanding of space sometimes exceeds the power of available computational algorithms. The development of specialized software at the University of London, the Georgia Institute of Technology, the University of Michigan, the Chalmers University of Technology in Gothenburg, the Universidade do Rio Grande do Sul in Porto Alegre, and other places around the world, makes the task much easier for those entering the field.

**Urban-Scale**

Space syntax analysis, such as that of street connectivity, is only useful when testable hypotheses have been developed over years of research. For example, research has established that pedestrian movement is more impacted by the number of turns than by distance traveled. Thus, streets from which other streets can be reached with fewer direction changes attract more people. Because they attract more people they tend to attract retail and other land uses that depend on the volumes of pedestrian traffic, and consequently the volumes of both pedestrians and uses are multiplied. This, in a nutshell, is the theory of “natural movement,” which helps to predict the likely effects of designs with regard to urban liveli-
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ness. Its power is based on rich descriptions of street connectivity. Space syntax measures go beyond measures of density, like the number of street intersections or the number of blocks per unit area to deal with spatial configuration. But why does the law of natural movement apply in the first place? Research indicates that we choose paths not only to reduce physical exertion but also to develop and maintain efficient mental descriptions of environments. Functionality and intelligibility are closely interlinked.

Interiors

Our analyses of building interiors often look at lines of movement, similar to the analysis of streets. In addition, we analyze visual fields. We consider the visibility polygons (or “isovists,” to use the term coined by Michael Benedikt, University of Texas at Austin) from each tile on a grid superimposed over usable space, and we measure their properties and patterns of intersection. The study of visual fields in conjunction with the study of how users occupy and move through space allows us to assess the patterns of what users are likely to be aware of and encounter in a setting. This is particularly relevant when we deal with work environments.

Our work with Steelcase on a workplace design suggested three principles for supporting knowledge-work and innovation.

• First, spatial design supports knowledge-work by sustaining frequent work-related informal interactions. Such interactions can be encouraged locally through controlled visual openness and the spatial grouping of workstations. Interactions across larger organizational units are supported by making the organization more spatially intelligible. This is achieved by designing legible plans with clear integrating cores or circulation spines, by distributing the people who are hubs of interaction networks in more prominent and accessible locations, and by bringing frequent paths of movement in contact with meeting spaces and informal gathering areas. It is not a matter of minimizing the distance between particular individuals to facilitate communication, as it was thought in the 1960s and 1970s. Rather, it is a matter of distributing opportunity for the organization as a whole.

• Second, spatial design supports knowledge-work by allowing visual traces of thought processes to be available in the background of commonly used spaces. This is further assisted by devices and equipment that help to carry and redeploy visual displays from one area to another as dictated by schedules of space-use.

• Third, spatial design supports knowledge-work by providing settings for different work styles, some proximate to the main spines of movement and hubs of activity and some at a distance from them, but all within the compass of a well-integrated plan.

Does this workspace support knowledge-work?

Should space syntax principles survive further testing, we have to ask why they work. Is it because they increase the speed at which successful ideas become known and absorbed by an organization? Is it because they make human resources, individual knowledge, experience, and skills easily available to other people? Both hypotheses would be consistent
with earlier work, including Tom Allen’s work at MIT in the 1970s. We think, however, that there may be more at play. The effects of spatial design may impact creative thinking (e.g., shifts in domain, lateral associations, metaphorical transfers). I raise these questions, which I cannot yet answer based on our research, to underscore that when space syntax engages problems that are specific to a field of practice or inquiry, it unavoidably interacts with new questions. These new questions require both extending space syntax techniques and interacting with other forms of data and other disciplines of analysis that relate to the question at hand.

**Why and When to Use Space Syntax**

With these caveats in mind, why and when would a practitioner or researcher use space syntax? Practitioners should consider using space syntax to evaluate how alternative design options meet explicit design objectives or to help generate design alternatives that address a specific problem. Space syntax is also applicable in fields of design practice that require collaboration, for example designing pedestrian-friendly environments in cities, or improving the intelligibility of complex wayfinding systems in hospitals. Space syntax researchers have made extensive inquiries into urban design, museum and exhibition design, work environments, and hospital design.

Researchers should consider using space syntax when their research requires that they describe with precision how spatial environments enable or impede users’ behaviors. Their research can contribute to the development of space syntax by making it increasingly sensitive to the spatial properties of the environment under investigation. Space syntax provides a unique foundation for evidence-based learning and design precisely because it provides a systematic framework for comparing environments and their performance.

**Examples of Space Syntax Research**

**Street Connectivity and Future Growth**

The Atlanta Beltline project, a 22-mile transit loop with trails and parks around the 19th-century city core, provided an opportunity to redesign streets and blocks to reconnect Atlanta’s neighborhoods by developing old industrial sites. The questions were which connections to make; which streets to create, extend, or realign; and how to configure them into a framework that brings together public value and private investment and allows flexible growth into the future.

In the map below, old industrial sites on the Beltline Tax Allocation District are shown in gray. The map is colored using the full color spectrum; red represents segments from which many destinations can be reached within a 1-mile path distance with only few direction changes; blue represents street segments from which few destinations can be reached without a large number of direction changes.
Space syntax was used to calibrate street layout master plans so that street connectivity and configuration provided a framework for flexible future growth. In the maps above, lines in red are the most integrated lines in their surrounding area and lines in blue the least integrated.

An improved distribution of more integrated lines will encourage pedestrian movement while alleviating vehicular congestion. Proposals for 20 areas similar to the one shown are being analyzed. The intent is that old industrial sites will not only absorb predicted volumes of urban growth, but also that the new street master plans will help to make Atlanta a more inviting city while re-tuning the relationship of existing neighborhoods.

**Office Design**
Recent research has shown that office layouts express organizational culture and affect employee satisfaction. The following two projects, for the US General Services Administration (GSA), examined whether the properties of layouts that are critical to social function are constrained by floorplate shapes on the one hand and office furniture systems on the other, so that the GSA can make more informed decisions.

**The Impact of Furniture Systems**
Sonit Bafna, Ph.D.

The layout of offices not only passively accommodates users, but also influences the social and organizational activities and patterns of work. Office layout can increase or limit the potential of unexpected encounters, contribute to general awareness, and ultimately help to create and maintain informal social networks that form the backbone of a productive organization.

Under a grant from the GSA, we developed general guidelines for office layout in two steps. First, we developed quantitative profiles of layouts with desirable properties. Second, we developed an inventory of typical design choices involved in a generic layout design and used statistical analyses to check which, if any, of these design choices were associated with the profiles established in the first step. Their results showed, rather unexpectedly, that local but repeatedly implemented design decisions, such as those regarding the shape of cubicles or the degrees of enclosures of workstations, have more systematic effects on the resulting spatial structure of the layout than global decisions such as the imposition of an overall circulation grid. This suggests that the design of furniture and office systems affects overall layout properties more powerfully than previously understood.
The Effect of Floorplate Shape
Ermal Shpuza, Ph.D.

The internal layouts of office buildings change over time such that we can clearly distinguish between building design and interior design. But how does building design influence interior design? Under a GSA grant, we studied the effect of floorplate shape on the structure of internal circulation.

In particular, we examined the degree to which the network of circulation lines were integrated to examine how many direction changes were required to access each circulation line. Such patterns of circulation have been shown to influence organizational function.

We created two measures of floorplate shape. One measure (Relative Grid Distance), tells us how compact a floorplate is. The other (Convex Fragmentation) indexes how a floorplate breaks up into distinct sub-areas. We found that the properties of floorplate shapes influenced the spatial properties of office layouts. However, different types of layout are affected in different ways, as shown in the accompanying illustration. “Biased layouts,” which are dominated by a few circulation spines extending in a predominant direction, are affected in different ways than “unbiased layouts” that have major circulation lines distributed evenly in both directions.

The measures of floorplate shape can be used to evaluate large building portfolios according to their suitability for different kinds of layouts. Though floorplates constrain office layout, designers can always work to overcome or accommodate constraints, depending on the specific requirements of a client’s organization.

About the Authors

John Peponis, Ph.D., is a professor of architecture and leads the morphology lab at the Georgia Institute of Technology. He received his doctorate in architecture at the University of London in 1983 and has been a registered architect in Greece since 1982. He is a member of the steering and refereeing committees for the International Symposia on Space Syntax, the World Society for Ekistics, and the editorial boards of Environment and Planning B: Planning and Design and The Journal of Architecture. He has published extensively on space syntax, design theory, and architectural theory and is the author of the book Chorographies: Descriptions of Space, published in 1997 (Athens, Greece: Alexandria Press).

Sonit Bafna is an assistant professor of architecture at the Georgia Institute of Technology. He received his SMArchS from MIT in 1993 and his Ph.D. from the Georgia Institute of Technology in 2001. His research falls broadly in the area of architectural morphology, particularly as it intersects with aesthetics, theory of criticism, and design inquiry.
Ermal Shpuza received a professional degree diploma in architecture from Polytechnic University of Tirana in 1992, an MSc in Architecture from The Bartlett, University College London in 1995 and a Ph.D. from the Georgia Institute of Technology in 2006. He is a registered architect in Albania and has practiced as an architect in Albania, Malta, and the US. Since fall of 2005, he has been an assistant professor in the School of Architecture, Southern Polytechnic State University.

More About Space Syntax
Space syntax originates with the work of a research team led by Bill Hillier at the University of London in the 1970s and 1980s. Hillier’s *The Social Logic of Space* (co-authored with Julienne Hanson) and *Space is the Machine*, published in 1984 and 1996 (Cambridge University Press) are the seminal references. The University of London is a center of syntactic studies, with a research laboratory (www.spacesyntax.org), a Master of Science degree, and a University-linked consultancy practice (www.spacesyntax.com). In the US, space syntax research is actively promoted in a number of universities including Georgia Institute of Technology and the University of Michigan, where space syntax is a field of the Ph.D. programs in architecture, as well as the University of Kansas and Texas Tech. *Environment and Planning B: Planning and Design* (www.envplan.com/B.html), founded by Lionel March and now edited by Michael Batty, publishes much of the most important technical work in this area of inquiry, while papers addressing specialized questions are published in journals such as *Environment and Behavior* (eab.sagepub.com), *Urban Design International*, *Ekistics*, and *Geoforum*. The 6th bi-annual international symposium on space syntax is scheduled to gather in Istanbul in June 2007 (www.spacesyntaxistanbul.itu.edu.tr). A rich record of symposia papers can be downloaded from the links provided in www.spacesyntax.net/symposia/index.htm

Related Research Summaries
“An Introduction to Space Syntax”
— *Environment and Behavior*

“Using Plans to Analyze Visibility in Buildings”
— *Environment and Planning B: Planning and Design*

“Wayfinding in Large Hospitals”
— *Environment and Behavior*

“How Visitors Move Through Open Plan Exhibitions”
— *Environment and Planning B: Planning and Design*

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— *Environment and Planning B: Planning and Design*

“Facility Plan Influences Learning and Socialization”
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